2000-06

Analyzing asymmetric operations

Bustamante, George A.

Monterey, California. Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

ANALYZING ASYMMETRIC OPERATIONS

by

George Bustamante Jr.

June 2000

Thesis Advisor:	Wayne Hughes
Second Reader:	Gordon McCormick

Approved for public release; distribution is unlimited.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE June 2000	3. REPORT TYPE AND DATES COVERED Master's Thesis

4. TITLE AND SUBTITLE: Analyzing Asymmetric Operations	5. FUNDING NUMBERS
6. AUTHOR(S) Bustamante, George A. Jr.	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release; distribution is unlimited.	

13. ABSTRACT ***(maximum 200 words)***

Current mathematical combat models and simulations have limited usefulness in analyzing asymmetrical operations, which exploit differences between friendly and enemy forces. The tools required to analyze these operations quantitatively are sparse and the underlying assumptions governing their application cannot be taken for granted. Conventional attrition models fail when applied to asymmetric activities such as Special Operations Forces (SOF) operations because SOF do not employ symmetric or attrition strategies. Successful SOF engagements achieve disproportionately large effects upon the enemy by creating and exploiting enemy weaknesses at decisive points. Some of these effects are: paralysis of enemy C3 networks, reduction of enemy morale, and suppression or even nullification of enemy combat effectiveness.

This thesis will first identify the factors that differentiate SOF from conventional force operations to show that these factors cannot be accounted for in existing models. The thesis will then propose a direction for analysts to take for those who wish to investigate the nature of asymmetrical warfare, emphasizing its nature as a miniature campaign, introducing suppression of the enemy quantitatively, and incorporating the role of relative superiority at every step in the operation.

14. SUBJECT TERMS Asymmetric Warfare, Lanchester Equations, Computer Simulation, Game Theory.	15. NUMBER OF PAGES 72
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited

ANALYZING ASYMMETRIC OPERATIONS

George A. Bustamante Jr.
Lieutenant Commander, United States Navy
B.S., United States Naval Academy, 1986

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN DEFENSE ANALYSIS

from the

NAVAL POSTGRADUATE SCHOOL
June 2000

Author: [redacted]
George A. Bustamante Jr.

Approved by: [redacted]
Wayne Hughes, Thesis Advisor

[redacted]
Gordon McCormick, Second Reader

[redacted]
Gordon McCormick, Academic Associate
Special Operations Group

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

Current mathematical combat models and simulations have limited usefulness in analyzing asymmetrical operations, which exploit differences between friendly and enemy forces. The tools required to analyze these operations quantitatively are sparse and the underlying assumptions governing their application cannot be taken for granted. Conventional attrition models fail when applied to asymmetric activities such as Special Operations Forces (SOF) operations because SOF do not employ symmetric or attrition strategies. Successful SOF engagements achieve disproportionately large effects upon the enemy by creating and exploiting enemy weaknesses at decisive points. Some of these effects are: paralysis of enemy C3 networks, reduction of enemy morale, and suppression or even nullification of enemy combat effectiveness.

This thesis will first identify the factors that differentiate SOF from conventional force operations to show that these factors cannot be accounted for in existing models. The thesis will then propose a direction for analysts to take for those who wish to investigate the nature of asymmetrical warfare, emphasizing its nature as a miniature campaign, introducing suppression of the enemy quantitatively, and incorporating the role of relative superiority at every step in the operation.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to improve operations by first examining the key factors that differentiate asymmetric forms of warfare, such as Special Operations Forces (SOF), from conventional or symmetric combat and then examining these factors from both a quantitative and qualitative perspective in order to develop a new analytical approach with modest predictive power. Currently, the analyst does not posses a valid analytical approach, let alone a model or heuristic, with which to treat the subject of asymmetric operations. Conventional attrition models are far from perfect, but do show, in general terms, the relationship between key elements of combat such as: the value of numbers, the effects of reinforcements and so forth. Asymmetric warfare, on the other hand, has not been subjected to the same level of rigorous analysis and attempts to apply conventional models to the subject have failed; often spectacularly. This comes at a time when U.S. analysts are increasingly called upon to address this "new" and nettlesome form of warfare.

B. WHY CONVENTIONAL ANALYSIS FAILS

The main reason that conventional analytical methods cannot deal with asymmetric warfare is that they concentrate on attrition of enemy forces. This methodology works to varying degrees when the combat being modeled is a shoving contest between two phalanxes in ancient Greece, trench warfare in WWI, or a slugging match between dueling artillery batteries. However, attrition models cannot readily explain: the results of the Gulf War, the effects of a coordinated cruise missile attack, or the outcome of a Special Operations Force (SOF) raid or rescue. Furthermore, the attrition-based combat models fail at various levels to address non-monotonic behavior and often exhibit chaotic behavior and instability as a result

of structural sensitivities of the models. The analyst requires a fresh perspective towards asymmetric warfare.

C. DESCRIBING ASYMMETRIC WARFARE

There are profound differences between asymmetric and conventional warfare. Asymmetric warfare is about relative position of friendly strength to enemy weakness, it is about surprise and deception and confusion that arises from the mismatch of strength to weakness and it focuses upon the relative rate of change of friendly strength and enemy weakness. Asymmetric warfare works by concentrating, not on the value of individual or aggregate units, but rather on the effects a chosen mode of combat has upon the capability of the enemy force. The outcome of asymmetric warfare is not determined by attrition of friendly and enemy units. It is determined by the loss or gain of *relative superiority*. Relative superiority is a concept developed by Captain William H. McRaven U.S. Navy. It is defined as: "... a condition that exists when an attacking force, generally smaller, gains a decisive advantage over a larger or well-defended enemy." (McRaven, p4) We will address this concept in detail in chapter one, but the critical point is that asymmetric warfare does not correlate strength to numerical or even qualitative superiority.

We do not presume that attrition is irrelevant in asymmetric warfare. Small forces in combat are extremely sensitive to casualties. Therefore attrition is not a determinant of success for the attacking SOF force, but it may be the dominant cause of failure. Since conventional models (and forces) focus upon the destruction of enemy units; it is clear that these models cannot be used to explain the dynamics of asymmetric warfare. In fact, a successful SOF operation may not involve any casualties at all.

D. THE CAMPAIGN APPROACH

We suggest that a more useful starting point is for the analyst to view a SOF mission as a "miniature campaign". The success or failure of this campaign hinges upon a sequence of critical events that must occur in order to attain and maintain relative superiority. Each of these events represents a step by step evolution of the situation, and each step is a "tally point" at which relative superiority is either gained, maintained or lost. In this sense, relative superiority is a zero sum game. What one side gains the other must lose. In a successful mission, the attacker progressively increases his relative superiority by wresting it from the enemy, who of course must lose an equal measure. If attrition does occur during the course of the battle, it is not an end in itself, but a desperate fight to improve one's position against the enemy. Furthermore, the ability of each side to inflict casualties upon the other is directly, but not necessarily linearly, related to the inferiority or superiority relative to the other. In terms of a Lanchester attrition model, the attrition coefficients are changing in direct relation to each side's relative superiority. This is occurring continuously, even if actual combat is not occurring. Furthermore, the attrition coefficients may be either discrete or continuous. An example might be the seizure of a critical radar site from the enemy. With the sensor, the enemy possesses enormous capability to inflict casualties upon the attacker and, therefore has a substantial attrition coefficient. But if the attacker can destroy the sensor, the enemy's guns and missiles are useless. When viewed this way, a pattern emerges and we can begin to glimpse an asymmetric combat model or a heuristic lurking in the shadows. The most promising feature of the proposed model is the rapid analysis of alternative friendly and enemy courses of action. Adding stochastic elements to the

asymmetric warfare hardly seems worth the effort because so many of the inputs are only weakly known.

E. THE TERRORIST EXAMPLE

Imagine a pair of individuals who decide to launch an attack upon a government building. The damage or destruction of the building and the slaughter of numerous government employees is the mission, because it has some symbolic or other importance to their cause. The attack is planned as a single shot explosive device to be delivered via a vehicle. In order to achieve their nefarious goals, the two men must successfully complete a

Terrorist Relative Superiority vs Time Plot

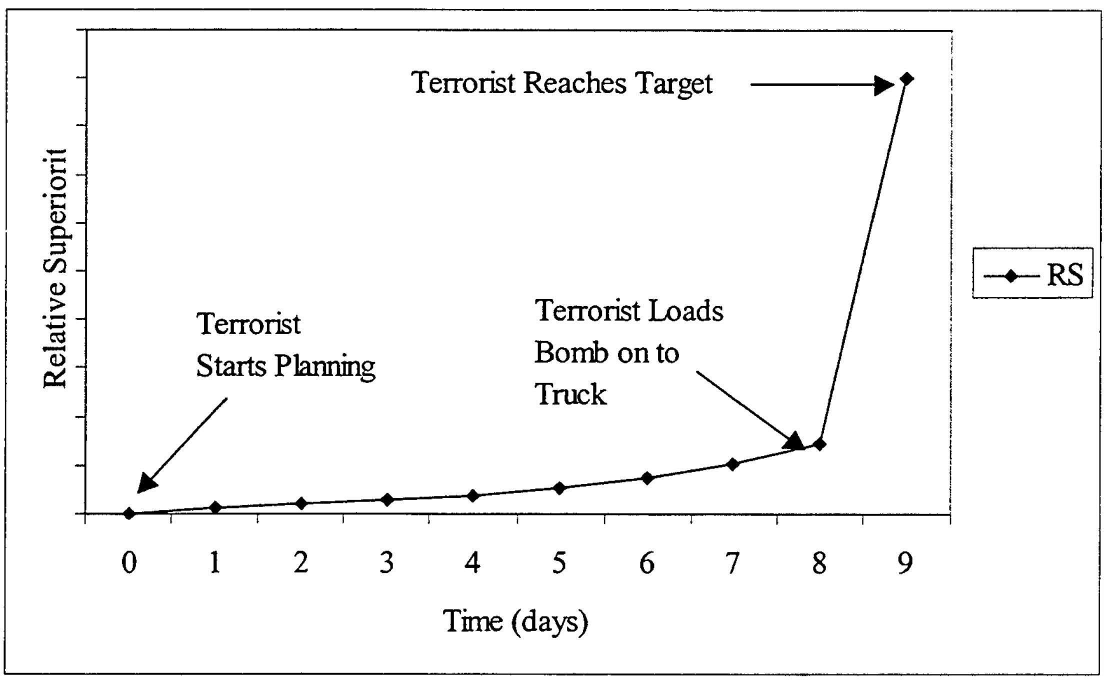

Figure 1.1

number of steps. In order: they must plan their mission, calculate the quantity of ordnance need to achieve the desired effect, find and assemble the explosives into a weapon, find a vehicle capable of delivering the weapon to the target, load the weapon and deliver it to the

target and detonate the explosive device. Figure 1.1 shows a relative superiority graph, a graph of attrition capability and a chart of casualties. At the outset of the mission, the terrorists are completely vulnerable; they have limited capability and are shielded from destruction by the inability of the government to find them. On the other hand, the government has an almost infinite capacity to destroy or capture the terrorists, once it locates them, but it is unaware of the terrorist safe house, and may even be unaware of the existence of the terrorists. The terrorists have no bomb, and no capability to affect the government in any way. Once the terrorists assemble the bomb, they possess the ability to inflict casualties, but not destroy their objective. This also represents the start of a window of terrorist vulnerability, if for example, the terrorists are found by the government to possess illegal bomb components, yet the terrorists at this stage are unable to affect the government. The terrorist experiences a modest increase in "combat potential", but it is still inferior to that of the government. As the terrorists load the weapon onto the vehicle and then drive towards the target: their superiority increases in proportion to the proximity of the target. The act of loading the weapon becomes an inflection point in the graph. Even if discovered, the media impact of their actions, although not as effective as destroying the target, may be still be useful. Once the terrorists are ready to blow up their target, their combat potential is fully realized and their superiority over the government is at its greatest. Note that the terrorist can still fail. Perhaps the explosive train fails, perhaps the building is unoccupied due to a fire drill. The key issue is that the terrorists achieve their greatest relative superiority when they are in position to convert their combat potential of a bomb ready to detonate into the combat power of an explosion at the government center of gravity. Also observe that in this

example, the only casualties occur at the end of the mission, unlike conventional attrition models that assume continuous attrition.

F. A NOTE TO THE ANALYST

This thesis will further develop a model with the intent of producing a product that helps both the analyst and the operator to understand what is happening in the real world. The analyst is reminded however, that there is no substitute for first hand experience. A trip to the field to observe SOF units training and preparing for combat missions will yield a significantly greater insight into the dynamics of actual missions than any modeling conjecture. It is the task of the operator to recognize this need and to provide an opportunity for the analysts to observe him at work.

II. ASYMMETRIC WARFARE AND SOF

A. OPERATIONAL STRATEGY

In the Bible at I Samuel 17:45- 48, we find:

> David answered him [Goliath]: 'You come against me with sword and spear and scimitar, but I come against you in the name of the LORD of hosts, the God of the armies of Israel that you have insulted. Today the LORD shall deliver you into my hand; I shall strike you down and cut off your head. ... All this multitude, too shall learn that it is not by sword or spear that the LORD saves. For the battle is the LORD's, and he shall deliver you into our hands

David's employment of an unconventional strategy to defeat his enemy is symbolic of the asymmetric approach to defeating a larger and "more powerful" conventional force. Our objective in this chapter is to provide the reader with a useful perspective on asymmetric warfare, and to introduce the characteristics of a SOF. We will start with our definition of SOF, then explain the underlying principals of how SOF employs asymmetric warfare, and finally, provide the reader with a perspective on the some key differences between modeling symmetric as opposed to asymmetric operations. This will allow us to set the boundaries of our discussion, and to convince the reader of the need to approach asymmetric warfare in general, and SOF missions in particular, with a different turn of mind. This chapter will serve as an introduction for the analyst to asymmetric warfare, and set the stage for chapter three of this thesis, which explains why conventional combat modeling techniques are inadequate for analyzing asymmetric warfare.

B. SOF AND ASYMMETRIC WARFARE

The first steps in our discussion will be to define SOF and explain why the employment of asymmetric strategy is inherent in SOF. The U.S. Special Operations.

Command (USSOCOM) definition of SOF is as follows:

> Special operations encompass the use of small units in direct or indirect military actions that are focused on the strategic or operational objectives. They require units with combinations of specialized personnel, equipment, training, or tactics that exceed the routine capabilities of conventional military forces. (SOCOM Pub 1 pg 1-1).

Two points stand out in this definition: the term *specialized*, and the decoupling of *objective* from a discussion of *combat*. Recall that we introduced asymmetric warfare not by discussing attrition, but by describing it as the position of friendly strength relative to enemy weakness; it is the surprise, deception and confusion that arises from the mismatch of strength against weakness. The USSOCOM definition of SOF describes an asymmetric force. Special Operations Forces seek to overcome the enemy by isolating and targeting a specific enemy vulnerability instead of defeating the enemy in detail. The emphasis of small units and "strategic or operational objectives" is another clue that a SOF operation is not about attrition, conventional forces being much more capable in that regard, but instead about achieving specific goals. SOF are supposed to be focused upon destroying or disrupting a very specific capability of the enemy force.

We intend to limit the focus of this topic to direct combat operations where the desired effect is the destruction of enemy capabilities. Examples of these omitted missions include a Special Reconnaissance (SR) mission to gather intelligence about a target, or a Foreign Internal Defense (FID) mission where SOF are employed to train or advise Allied Nations (AN). We note that SOF are frequently employed in missions that may involve combat, but combat is not the objective of the mission and is logically outside the realm of this analysis.

C. CHARACTERISTICS OF SOF OPERATIONS (WHAT MAKES THEM DIFFERENT)

A brief comparison of SOF and conventional forces, beyond the composition of the respective forces, must include a general discussion of what makes a SOF operation different from a symmetric strategy. We start first with a broad discussion of the principles of war as defined by the U.S. Joint Chiefs of Staff. The principles of warfare serve as a useful prescription of how to employ military forces, and help military commanders discipline their thinking about operations. The difference between the conceptual point of view of SOF and conventional commanders offers a substantial insight into why conventional models fail to work for modeling asymmetric strategies.

The principles of war are a set of precepts that can be applied to warfare in general, and which every commander ignores at his peril. To varying degrees, the value of these principles is that they are thought to be applicable across the spectrum of warfare whether on land, at sea or in the air. They are relevant at the tactical, operational and strategic levels of war. They can be applied to conventional and irregular warfare, but with a different emphasis on each of them. They can be identified in historical military operations and the success or failure of those operations can be traced directly to the application or misapplication of the principles of war. The principles of war are succinctly defined in of Joint Publication 3-0, Doctrine for Joint Operations:

> The principles of war currently adopted by the Armed Forces of the United States are objective, offensive, mass, economy of force, maneuver, unity of command, security, surprise, and simplicity. These principles deserve careful study by all who practice the military art, because the insights suggested by their analysis span the entire range of military operations. (Joint Pub 3-0, chapter three)

What is so significant about these principals and SOF, is not the omission or replacement of these principles, but rather a different emphasis and interpretation of these principles for a SOF.

Other principles that guide SOF operations are different from the JCS principles because SOF are inherently *high leverage forces*: they seek to achieve significant results with limited forces, often with substantial risk to those forces. By definition, special operations, and to a larger extent asymmetric warfare, are "economy of force" operations. This is the essence of the *coup de main*: "small parties of warriors, operating with limited resources and without hope of reinforcement, have repeatedly conducted sudden strikes-frequently deep within enemy lines-relying on shock, surprise, speed and maneuver to defeat an often numerically superior enemy". (Vandenbroucke, pg 3) McRaven emphasizes six principles for SOF: Surprise, speed, purpose, security, repetition, and simplicity. (McRaven, pg 8-23) The intersection of the descriptions provided by Vandenbroucke, McRaven's principles and the JCS principles emphasizes mass (shock), surprise, speed (relative to the enemy reaction capability), and maneuver. We will proceed with a discussion of these principles and how they apply to special operations.

The first factor, mass or shock, means that SOF can delivery disproportionately large amounts of intense and focused firepower relative to their size, but they cannot sustain it due to their small size. This firepower must be husbanded and applied at the critical instant and at a decisive point. Otherwise, over time, superior enemy combat power will nullify the SOF. Nor is the essence of SOF combat power its destructive capability. There is a physiological and suppressive effect that temporarily disrupts the enemy will to resist and function in a coordinated manner.

The second factor, surprise, appears to be simple, is not. Surprise arises not only because the enemy cannot physically see the SOF coming. Surprise may be achieved by virtue of the enemy failure to recognize the SOF as a significant threat and downgrade the SOF in priority of engagement. Chess provides an example of this when players fail to recognize the ramifications of an opponent's move even though all the playing pieces are in plain sight. Moreover, surprise is an enabler for SOF to deliver its attack.

The next factor, speed, is not simply velocity; it is flexibility to recognize, respond and adjust the disposition of forces. The application of speed creates a sort of paralysis in the enemy chain of command that allows the SOF to maintain a temporal advantage and survive to complete the mission.

Finally, maneuver is not so much the agility of SOF, but the ability of SOF to move as planned without interference from the enemy. This advantage may come from the use of gliders, parachutes, submersibles or other vehicles with exceptional capabilities, or it might arise from the ability of a SOF to blend into indigenous populations. Taken together, these factors delineate the characteristic of SOF operations that the analyst must keep in perspective when modeling SOF: the need for a temporal advantage over the enemy, which enable SOF to expend their limited combat power on the enemy center of gravity. This is a fundamental difference between symmetric and asymmetric warfare.

D. MCRAVEN'S CONCEPT OF RELATIVE SUPERIORITY

William McRaven's concept of relative superiority is a very useful analytical tool for describing how a SOF gains its advantage over the enemy: "Simply stated, relative superiority is a condition that exists when an attacking force, generally smaller, gains a decisive advantage over a larger or well defended enemy." (McRaven pg4) Relative

superiority is a temporal and transitory advantage. SOF cannot sustain it indefinitely, and don't attempt to. The need for relative superiority lasts only as long as the mission, and under the worst circumstances, is only required until the SOF achieves its desired effect at the enemy center of gravity. The principles of SOF are the factors by which relative superiority over the enemy is attained. In essence, relative superiority is a wild card that is substituted for the other principles of war that the SOF is unable to exploit. Relative superiority over the enemy amplifies SOF combat power and disrupts enemy combat power. It prevents the enemy from responding in a coordinated manner. We will incorporate the idea of relative superiority as the critical variable in chapter three. It is our measure of effectiveness with which to discuss the operational characteristics of SOF as opposed to symmetric combat forces.

E. INITIAL ANALYTICAL IMPRESSIONS

Having defined SOF and discussed some of the operational principles they employ, we summarize the differences between SOF and conventional forces and how these differences might translate into quantitative models. These differences underscore our basic thesis: the need for a new analytical approach for asymmetric warfare. This will also help the analyst to frame the key features of a SOF force.

One of the distinguishing features between a SOF and a conventional force is the number of entities actually or potentially engaged in combat. Conventional forces generally contain numerous entities. They are often modeled as a continuous action between two large homogenous, aggregate forces. On the other hand, SOF forces are generally small units, and are always numerically inferior to the much larger conventional forces they confront. This suggests that SOF entities should be treated as discrete entities. Not only are SOF entities

few in number, the special capabilities inherent to a SOF are generally specific to individual tasks performed within the SOF. The result is that mission success probability often decreases rapidly with the loss of only a few members of the SOF.

A second fundamental difference between SOF and conventional forces is the result of an attrition strategy versus asymmetric strategy: a cumulative vs sequential measure of success. The objective of conventional combat formations is symmetric: both sides seek victory through cumulative attrition. Large conventional forces that seek victory through attrition engagements can be represented as "target serving queues". The enemy forces can be modeled as heterogeneous or homogeneous, but the effect remains the same: enemy forces are attacked ("served") as they present themselves to the firer. In this scenario, time can be compressed or extended to allow us to represent each force engagement with independent, identically distributed variables ("iid") which greatly simplifies computations. Engagements are sustained in the models as long as exchange rates are favorable, or at least sustainable, and each side has forces capable of fighting.

By comparison, SOF engagements are "sequential", and the objectives of the SOF and the conventional enemy are not identical. There are two different measures of effectiveness employed: the conventional enemy seeks attrition, but the SOF is focused upon a specific enemy center of gravity. Time is critical because events must be completed sequentially or simultaneously for mission progression. This in many ways resembles a system reliability model where components must work (or fail) for the operation to succeed (or fail). Events are not independent; the successful completion of each task (called an event) is conditional: it depends upon the outcome of previous tasks (events). Nor will the SOF voluntarily sustain an engagement once it has achieved its objective. An opportunity to

engage a high value target of opportunity might, in extreme circumstances, entice a SOF to engage, but normally the SOF will simply complete its mission and retire.

A third characteristic of SOF style warfare is the special effect of terrain and weather. While weather and terrain may be critical factors for conventional forces, these may be accounted for in attrition coefficients and exchange ratios. On the other hand, SOF often chose to conduct an operation based upon the presence of weather or terrain conditions that will favor an operation. For SOF, this is not a "force multiplier" that can be accounted for in an attrition coefficient. SOF mission success or failure may depend upon the ability of a small force to exploit terrain and weather to enter a denied area or evade the enemy.

In chapter III, we will review the various attrition models generally used by analyst, and explore their limitations for modeling asymmetric warfare. The reader should keep in mind the unique circumstances that affect SOF as we proceed.

III. THE PROBLEMS WITH ATTRITION MODELS

A. PURPOSE, POTENTIAL AND POWER

This chapter will build upon the factors introduced in chapter one and show why attrition models are inherently unsuitable for modeling SOF and other forms of asymmetric operations. One underlying principal of attrition models is that combat power is so readily derived from combat potential that they are treated as one and the same. Yet, successful SOF operations depend on full activation of the SOF combat potential, while inhibiting the activation of enemy combat potential. When a SOF successfully achieves this goal, the SOF is able to convert combat potential into combat power, while the enemy, regardless of his advantage measured in combat potential, is unable to convert it into combat power. The result is that the SOF is able to achieve local superiority in combat power. The relationship between combat power and combat potential is not adequately addressed by combat models and simulations, but is nonetheless vital to obtain any useful analysis of asymmetric combat operations.

B. THE LANCHESTER MODELS

When Lanchester formulated his "modern" attrition models in 1914, his purpose was to quantitatively demonstrate the value of concentration of forces. (Operations Research Department, p61) Lanchester wanted to contrast ancient warfare, which he described as a series of individual duels, and modern warfare where weapons distributed across the battle field could concentrate upon individual enemy entities: these models became the Lanchester linear law and the Lanchester square law respectively. (Operations Research Department, p61) The linear law assumes that combat is a set of one on one duels where unengaged forces cannot contribute their combat power to the battle. The relationship between the loss

rates of side x and side y are related by attrition constants α and β respectively. The number of casualties inflicted is a function of the total number of combatants engaged so:

$$dx/dt = -\beta\, x(t)y(t) \qquad\qquad dy/dt = -\alpha\, x(t)y(t) \qquad\qquad [3.1]$$

In contrast, the square law assumes that every combatant can see and attack every opposing combatant: there are no unengaged forces. Every combatant can contribute its combat power to the battle. In this case, the rate of casualties inflicted on a side is a function of the total number of shooters and their ability to destroy the enemy. The combat power of the individuals on the two sides are described by the attrition constants α and β. All forces are engaged so the casualty rates can be expressed as follows:

$$dx/dt = -\beta\, y(t) \qquad\qquad dy/dt = -\alpha\, x(t) \qquad\qquad [3.2]$$

These models established a relationship between the rate at which the engaged forces inflict casualty as a function of combat power, represented by attrition coefficients and the engaged forces. (p60)

Lanchester assumed that the attrition coefficients were a measure of individual combat power influenced by rate of fire, accuracy and munitions effectiveness. Most importantly, these attrition rates were ***constants***. Also of interest, the equations imply that every combatant can kill every other combatant. We contend that these modeling assumptions oversimplify combat and will revisit this point in chapter three.

Lanchester's models have also been modified to include the mixed law case were one side can engage all of the other forces with aimed fire, but the other side is only able to use area fire. Lanchester models have also been modified to include heterogeneous forces, but Lanchester's original precepts have not been significantly altered. Attrition coefficients are

generally held to be constants and they are independent of enemy action to attenuate the effect by, for instance, taking cover.

C. LANCHESTER: THE GOOD, THE BAD AND THE UGLY

From this brief introduction, it is obvious that Lanchester equations have desirable and undesirable characteristics for the analyst. Lanchester equations are fairly straightforward, and useful for demonstrating the benefits of general principals, for example, the value of numbers, the value of firepower, when to commit reserves and so forth. And since the equations are simple, they require minimal processor power. This allows for speedy execution of problems and gives the analysts the ability to quickly vary a host of parameters and obtain results.

The negative aspects of the Lanchester equations also stand out. These problems fall into four broad categories: the assumption of continuity in time, the derivation of the attrition coefficients and the assumption that the enemy cannot affect the coefficients by, for example, staying out of sight, the modeling of these coefficients as constants, and the inability of the models to show any effect or relationship between the combat potential of each side and the actual combat power served up. We will address these issues sequentially.

The first and foremost problem is the assumption of continuity of time from the beginning to the end of the battle. In Chapter Two we challenged this assumption and noted that SOF operations tend to be episodic: brief engagements may permit us to assume that time is continuous, but we cannot consider time as a continuous variable over the length of an entire mission. Combat in SOF operations generally represents a small fraction of total operation time. It is therefore a gross misrepresentation to assume that the attrition rates are continuous and simply a function of time and enemy firepower.

The next consideration is the effect of constant attrition rates and how they are rationalized. The problem is that attrition coefficients are generalized to represent the combat power of the combatants over an extended period of time and without regard for actions taken by the targets in order to survive. The application of various statistical curve-fitting techniques to determine "constant" attrition coefficients also leads to problems with predicting the future. In general, this results when coefficients which give excellent fit under one set of conditions, are used to represent attrition rates where the battlefield conditions or the enemy's posture have changed.

Even when using heterogeneous models, the use of constant attrition coefficients in the models white washes the actual conditions on the battlefield. There is almost always a gross oversimplification of the battlefield dynamics, which may have a much greater impact on the attrition rates than numbers of forces, and are almost constantly in flux. Imagine a duel between two ships of the line that takes place under deteriorating weather conditions. Sea state and visibility may make combat altogether impossible!

The final problem is that the combat potential of the forces is converted directly into combat power. This is a suspect assumption given the lessons of history. Changes in combat conditions, leadership, morale, communications and many other effects, whether they occur as a result of nature or the intention actions of the enemy, have a beneficial or negative impact upon the ability of the combatants to translate combat potential into combat power. For asymmetric operations, where the objective is to disrupt the combat potential of the enemy, this un-modeled limitation hamstrings any meaningful analysis.

It is apparent that the classic attrition models derived by or from Lanchester's work are insufficient for an asymmetric combat model. Lanchester's work is valuable, and may

apply to true attrition campaigns like Iwo Jima or the Western Front of WWI, but questions about the validity and utility remain. And Lanchester's model does not adequately address combat operations where attrition through firepower is not the measure of effectiveness. Many modern combat models and simulations have employed high resolution, accounting for the characteristics of each entity engaged in combat, as a means to deal with these problems.

D. HIGH-RESOLUTION MODELS

High-resolution models seem to offer a viable alternative to the Lanchester equations. However, these models also come with a host of problems that limit their usefulness in analyzing asymmetric operations. We must briefly address these models in order to complete our discussion of attrition models, and suggest that the analyst carefully consider the risks inherent in this approach. Of particular concern is the "design philosophy" of the high-resolution approach. We suggest that high-resolution models still suffer from a focus on attrition, rather than the more relevant concern of asymmetric operations: the destruction of the enemy capability to resist.

Essentially, high-resolution models attempt to represent combat by treating each combatant as an individual entity, and maintaining a detailed accounting for a plethora of variables that influence the behavior and effectiveness of the entity. These models tout the promise of "realism" or detail, and incorporate physical factors such as smoke or terrain. Finally, the effect of each action or event is tracked so that the future effects of past and current actions is preserved. Often these models employ a stochastic element, to account for variability on the battlefield. (Operations Research Department, p1) The attraction of these models is obvious: they seem more real than simple exchange ratios and firepower scores

offered by more conventional attrition models. But there are also problems attendant in the models and the approach.

The first problem with high resolution models is that they are focused on attrition. One can argue that the models can be adapted to account for behavior of the entities and can incorporate asymmetric strategy into the model. We believe that the analysts and programmers are treading on thin ice when making such claims. This assumption is stretched to the limit when we consider the incredible strains placed upon the individual soldier, sailor, airman or marine engaged in a vicious life or death struggle. We can't even begin to predict the subjective interactions introduced by fear, and the will to win.

The complexity of these models also requires large computer programs that are difficult to develop, test, maintain, and run. (Operations Research Department, p1) A simple model like Lanchester lends itself readily to rapid analysis techniques and allows for almost instantaneous sensitivity analysis. High-resolution models require more time and are either subjected to less rigorous analysis, or require the analyst to make a greater investment in time and money to investigate the output of the models. This leads to two significant problems: validation of the model, and interpretation of the data. (p3) With so many variables, how does the analyst get a clear picture of the results, and worse, verify that the model is performing correctly?

A simple programming error may cause unintended results that are difficult to track down. An example might be that a unit starts moving backwards or stops after encountering a specific terrain type making it more vulnerable to destruction. The error is missed because the unit is inevitably targeted and destroyed due to its vulnerability. Unless the analyst checks the movement, firing results and position of every entity, and at each time step, this

error may go undetected; but later play a major, yet undiscovered role in influencing the outcome of the simulation run. These difficulties are compounded by the need to make multiple simulation runs when the model incorporates stochastic elements. (p1) A simulation that incorporates random variables introduces variances that may mask changes to a single variable. Thus the simulation must be run multiple times to eliminate the effects of a "Hail Mary" shot or an unlikely miss and assess the change in a single variable. Even worse are the problems caused by non-monotonicity and chaos as a result of these stochastic elements and numerical inaccuracies caused by computer simulation. (Dewars, Gillogly and Juncosa, pg 37,38) These factors make high-resolution models difficult to employ and interpret.

Perhaps the worst aspect of high-resolution models is the extraordinary time required to conduct meaningful analysis of the data. (Operations Research Department, p1) The vast number of variables incorporated into simulations not only makes sensitivity analysis time consuming, it also makes it more likely that errors in programming will be overlooked. The effect is magnified many times over when random variables are introduced, and additional runs must be made to allow for variance. The analyst runs a significant risk of becoming mired in solving problems that are not directly related to the operation, but rather arise from computational issues inherent in the simulation. And the end user is forced either to wait for the answer, accept incomplete analysis, or hire more analysts and pay for increased computational power to get results. This hardly seems worth the effort given the costs, particularly when there is no guarantee that a computer simulation can give more accurate results or reveal any trend or other effect worthy of increased study. For all their problems, mathematical models seem to remain competitive with computer simulations.

E. SUMMARY

We believe that attrition models and simulations are of very limited help in analyzing SOF operations whose effectiveness is independent of or only partially dependent on attrition. These models were not intended to predict or describe asymmetric operations and we ought not expect them to be applicable except for the rare occasion when a SOF operation incorporates a phase of conventional combat. To cut the Gordian knot we will have to develop a new model and methodology. The following chapter will introduce a model based upon a campaign approach to modeling asymmetric operations.

IV. THE CAMPAIGN MODEL

A. PURPOSE

The purpose of this chapter is to develop a model that captures the key factors of asymmetric warfare and relates them in a useful way to combat. One of the central themes established in chapter one of this thesis is that attrition is only one of many factors in asymmetric warfare and attrition is not the most important factor in determining the outcome of a SOF operation. This suggests that a Lanchester-like relationship between numbers of forces and their collective ability to inflict physical harm upon the enemy is inadequate. In order to capture the true essence of asymmetric warfare and relate it to conditions on the battlefield, we must take into account the relative advantages and disadvantages of the attacker and defender and consider them as variables. McRaven's concept of relative superiority seems to be a logical choice as a unifying variable expressing the dynamics introduced by the asymmetric nature of SOF combat (McRaven, pg 4). The question that flows from this argument is how does the relative superiority (RS) variable interact with, and relate to other variables?

There is also another dynamic of combat that needs to be reviewed: the contribution of suppressive fire upon the enemy. For SOF, this is a critical point; small units simply lack the organic firepower to destroy a large conventional force in detail. More importantly, destruction of an enemy fighting force is seldom the purpose of a SOF operation. SOF relies upon establishing relative superiority to win, aided by the suppression of enemy firepower when combat is occurring. A successful SOF mission attacks the enemy at several levels; it strikes the enemy center of gravity, it neutralizes the enemy's ability to inflict damage, and

when necessary, it strikes down the enemy himself. In order to establish a mathematical model, we must describe asymmetric combat in a way that incorporates these properties.

B. THE CAMPAIGN APPROACH

As a starting point, we suggest that a SOF mission should be viewed as a miniature campaign, and modeled accordingly. This naturally flows from the typical mission analysis conducted by SOF forces (NAVSPECWAR Patrol Leaders Handbook), where the critical enemy centers of gravity are identified and the steps necessary to destroy or neutralize them are chosen. The operation is described as a series of events upon which the success or failure of the mission hinges. Each event represents a radical change and critical point in the dynamics of the battle and is seldom the result attrition, but rests upon other factors that *radically alter* the relative combat power or potential of the combatants. The dynamic of asymmetric combat seeks to directly reduce the enemy ability to act effectively as opposed to conventional combat, which seeks to destroy the enemy directly with superior force and fire.

We would be remiss not to point out that in certain situations, the desired SOF effect is attrition. But this is not the emphasis of our work. The enemy conventional force possesses enormous combat potential, which if realized, can be translated into overwhelming combat power. The SOF has much less combat potential, but that potential is completely transformed directly into combat power and focused on the enemy center(s) of gravity. The SOF force seeks to exploit its advantage asymmetrically, by applying its unique capabilities directly to the vulnerabilities of the conventional force while never allowing the conventional force to translate combat potential into combat power. SOF possesses capabilities, both physical and psychological, that can be brought to bear to destroy the linkage between enemy

combat potential and combat power. In terms of this conceptual approach, relative superiority measures the degree to which one side has disrupted the combat potential – combat power linkage of the other.

Relative superiority is a temporary advantage that allows SOF to move beyond simple attrition and attack the enemy center of gravity directly. If relative superiority is sustained over a prolonged period, the asymmetric force may indeed reduce the conventional force through attrition, but this is a derivative benefit. Asymmetric combat employs relative superiority to affect the situation by: 1) allowing the SOF to fully leverage its combat potential and translate it into combat power at the expense of the other side, 2) disrupting the combat potential of the opposing side by denying it the ability to employ its forces effectively and 3) demoralizing the enemy forces that are able to reach the battlefield with an attendant loss of effectiveness (combat power).

Relative superiority can be assessed for key events where the relative advantage between adversaries can be predicted to change. Relative superiority is a zero sum game: as one side gains it, the other side must in equal measure loose it. These critical events are effectively inflection points where the relative superiority changes value with the loss, gain, or maintenance of advantage. This concept describes the essence of the *coup de main* that allows a small, elite force to leverage its combat power against a larger force for a short period of time (McRaven, pg 4-8). Relative superiority is therefore a dependent variable whose value changes as the operation progresses from one event to the next. Since these events are finite and countable, we consider them to be individual states. It is clear that relative superiority is a state-dependent variable that has a profound impact upon the forces

locked in, or potentially locked in, combat. To establish this relationship we step into graph theory.

C. A GRAPHIC DESCRIPTION OF THE "CAMPAIGN MODEL"

The SOF mission can be represented as a *directed graph* in which each event is a node and each arc represents some probability of progressing to the next state. Nodes represent critical events that occur during the course of a mission. Each of these events represents the step by step evolution of the mission. Each step is a "tally point", a change of state, at which actual or potential superiority is either gained, maintained or lost. For example, attaining surprise or gaining some geographical advantage should constitute a node in the graph. Figure 4.1 represents the simplest case, a directed graph, in which the mission must progress from the starting node to the finish. This is not only the simplest case, it is

Simple Event Graph Model of Asymmetric conflict

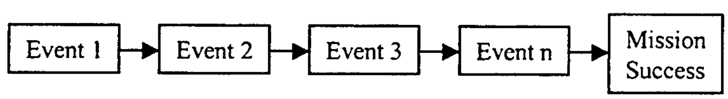

Figure 4. 1

also the ideal case because there is no deviation from path and the outcome of the mission is assured. A SOF operation is rarely as simple as described by this graph. In reality, there may be multiple paths to the objective, and there are normally paths that do not lead to mission success. In reality, there exist *absorbing states* in which the SOF is placed at such a disadvantage as to prevent the mission from continuing. We will introduce a brief example to demonstrate several concepts.

D. THE TROJAN HORSE AS AN EXAMPLE OF ASYMMETRIC WARFARE

The story of Odysseus and the Trojan Horse is the first SOF mission described in

Western literature, and provides an excellent model of asymmetric warfare. Recall that the objective of Odysseus's SOF was to sneak into the city of Troy, undetected in the belly of a hollow wooden horse, seize the gates, and signal for the return of the Greek fleet. Figure 4.2 shows the event graph for the Trojan Horse. When broken down into component events, it is clear that mission success hinges upon keeping the Trojans in the dark until Odysseus's force can seize the city gates and signal the Greek fleet, followed by a surprise attack on the open gates. It is also clear that the relative superiority of the Greek force increases the longer the ruse continues. If discovered at the outset, Odysseus's force faced almost certain annihilation while hidden within the Trojan Horse. Both the Greeks and the Trojans would

Event Graph Model of Trojan Horse Mission

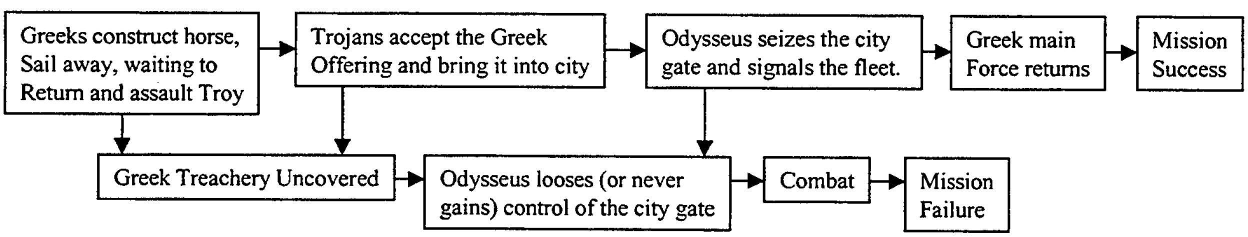

Figure 4.2

have been able to completely translate their combat potential into combat power, but the disparity of combat power was so enormous that the Greeks would not have had a chance of survival, let alone success. Our premise is that Odysseus can, and ought to, evaluate the probabilities of success at the critical nodes in order to *compare the expected risk against the reward.*

Once the Trojans accept the horse and bring it into their city, the dynamics of the operation shift radically. At that point, Odysseus and his force begin to constitute a threat to the Trojan center of gravity: the city gates. Although his threat is miniscule at the outset of

festivities due to the disparity between the Greeks and Trojans, Odysseus is in the game, and the Greek relative superiority begins to increase, at the expense of the Trojans. The Trojan's state of readiness deteriorates as wine and festivities befuddle the Trojans, and the onset of night increases the potential for surprise and confusion. The ability of the Trojan army to recognize the Greek threat and then respond in a coherent and coordinated manner is increasingly disrupted.

When Odysseus emerges from the horse, his small force is able overwhelm the few Trojan soldiers on watch and seize the city gate. At this instant, the Greeks realize relative superiority over the Trojans: not only do they seize the enemy center of gravity, their ruse fully exploits the weakness in the command and control network of the enemy: the Trojans cannot mobilize to mount a coordinated counter-attack. The Greeks fully leverage their combat potential and translate it into effective combat power, allowing them to engage the Trojan forces sequentially, and defeat them in detail. The seizure of the city wall in real terms corresponds to a reduction of both the combat potential and combat power of the Trojans without their fortifications. The Trojans are simply unable to mount an effective defense against the entire Greek army. Yet the ultimate success of the Greeks depends upon Odysseus's ability to sustain his relative superiority over his enemy until the main Greek army arrives. The small Greek formation is vulnerable to attrition and cannot sustain the defensive indefinitely. Realizing that Odysseus' SOF could not maintain relative superiority indefinitely, it is obvious that a speedy relief was a key factor in the Greek success.

This example shows several key features of the campaign modeling approach to SOF operations. It suggests that SOF missions are episodic: very little combat occurred during the course of the mission and the combat potential of the forces varied over a wide range. The

example shows the close correlation between relative superiority and combat potential and combat power. The example also suggests that a variety of analytic tools may be required to analyze the nodes as well as the transition probabilities from node to node. In the next section, we suggest some of the analyst's means of analyzing the activities that occur at the nodes.

E. ACTIVITIES AT THE NODES

The campaign analysis model is highly sensitive to activities that occur at the nodes, and although we cannot be exhaustive, we will suggest several methods of analysis. The reader should keep in mind that our approach has not been to force a situation into a model, but to remain flexible and model the situation. Since a node may represent any number of events from the reliability of a single weapon system to the probability that a force achieves surprise, to the outcome of an engagement; a skilled analyst will apply the methodology most appropriate to the situation. There are at least three broad categories of analysis that stand out as being particularly useful: the first is judgment: defined for our purposes as a commander's estimate, the second is a "conventional operations analysis approach" using statistical analysis, stochastic models, and optimization, the third category is a combat modeling approach. These broad categories are neither exhaustive nor is one approach superior to the other. In fact, all three categories will probably be required in any serious analytic effort.

F. METHODS OF ANALYSIS

One method of analysis is judgment. Some analysts will be loath to abandon traditional mathematical tools in favor of a more holistic approach, yet there exist many cases in war where professional judgment is not only appropriate, but may be the only method of

proceeding. Several instances of this will be seen in the example case study in Chapter Five. This situation often arises over questions of surprise or likely enemy responses or preparations. Intangibles that have a proven effect on the outcome of an engagement: leadership, "fog of war" and so forth are: "beyond one's ability to represent and test analytically." (Dewars, Gillogly and Juncosa, p37, 38) The analyst might employ sensitivity analysis to obtain a range of outcomes and proceed from that point. However, the most appropriate solution to the problem will almost always require the expert judgment of commanders and the SOF itself. The analyst simply cannot delude himself or herself as to the existence of a "correct" solution obtainable by quantitative methods alone. SOF missions are economy of force operations: they get high leverage out of small forces (Arquilla, pg xvi). This leverage effect often depends upon one or more intangible factors that are hard to define or impossible to quantify. The message is clear: leave these judgments to those best able to render judgment.

The Trojan horse is a prime example of the need for judgment: what analytical tool can be applied to assessing the Trojans' willingness to accept the horse and bring it within their walls? This highlights the need for analysts to conduct fieldwork and to closely coordinate their analysis with the SOF they are supporting.

A second method of analysis is the application of more conventional analytic methods such as game theory, stochastic models, optimization and statistical modeling. SOF missions, particularly U.S. SOF missions, often contain long-range insertions of forces or other elements that lend themselves to more conventional analysis tools (Arquilla, p55). The reliability of a given insertion platform, the probability of evading or defeating a given sensor to achieve surprise, or the expected number of SOF delivered on target are examples of

estimates that lend themselves to quantitative analysis. Often this information must be gathered by visiting the units in the field to gather data. As an example, helicopter reliability data for routine training missions might not accurately reflect the conditions present in a planned operation. Again, fieldwork by the analyst is required.

Another method of analysis is the use of combat models such as the Lanchester equations. Although we contend that attrition is not, or least should not be, the focus of asymmetric warfare, most cases will require attention to the subject of casualties. Often, the SOF will have to overwhelm a garrison defending a target, or defend a seized objective for a short period of time while awaiting the arrival of conventional forces. These missions require that attrition be accounted for, as this will influence the timetable for relieving forces, or the necessity of additional fire support. There is also the case of "what if" something goes wrong in the course of the mission and the commander needs an estimate of how his forces will perform, if called to fight at the inopportune time or against larger forces than expected. This sort of analysis is done to assist a commander in determining viable options, for example to continue an operation, albeit at an increased risk of casualties, or to employ a different tactic or weapon to achieve the objective. In the next section entitled: ATTRITION AT THE NODES, we suggest some modifications to Lanchester equations that will more appropriately model attrition.

As the campaign model is developed and used, other methods will be developed. The important point is to escape the conceptual restrictions of conventional warfare models, simulations and techniques for symmetric warfare by doing a better job of describing the real process as a mini campaign. To this end, decisive phenomena such as relative superiority,

preservation of temporal advantages, and the ability to stay one step ahead of the enemy become critical elements of the analysis.

G. ATTRITION AT THE NODES

We next address attrition at the nodes, not simply as an analytical tool, but because it provides a different perspective of the effects of asymmetric warfare. When attrition occurs at the nodes there are several mathematical models that may be applied. However, thinking about attrition in light of the concept of relative superiority requires a few changes in perspective. A review of the key variables that influence asymmetric combat shows that there are five that may be used to describe an engagement and which directly affect its outcome. Figure 4.3 lists these variables. These variables, and how they relate to and shape

Key Variables Influencing Asymmetric Combat

1. Number of combatants.
2. Combat power of combatants.
3. Relative superiority of forces (zero sum game).
4. Suppressive fire effects of the enemy.
5. Time.

Figure 4.3

the engagement, are in the broadest sense, captured by Lanchester equations and aggregate combat models. However, these models fail to address the relationship of relative superiority and the effects of suppressive fire on the battlefield. The fundamental problem is that attrition coefficients and firepower scores have been modeled as constants. Yet the concept of asymmetric warfare suggests that this is not the case. Asymmetric warfare is founded upon a stratagem that attempts not only to affect enemy numbers through attrition, it focuses upon the destruction and disruption of enemy ability to translate combat potential into combat power. Each individual's combat power should be considered as a variable, not as a

constant. Moreover, it is a variable that can be affected by the opposing force. Even high resolution combat models with highly detailed models for each entity fail to capture this essential variability.

Geography also affects relative superiority. Imagine the Spartan King Leonidas with his 300 men defending the mountain pass of Thermopylae against the Persian hordes: at one point in the battle, only two warriors can face each other across a narrow path, but as the battle continues and the Spartans are forced back, the path opens into a small clear area that allows more infantry and perhaps archers to engage. It is obvious that the combat power of the forces must change to reflect the change in terrain. SOF battlefield dynamics change, often radically, and this affects not only the numbers engaged, but the effectiveness of the individuals (e.g. the effect of archers). For SOF, sneaking past an enemy unit can be every bit as effective as destroying that unit. In fact, the real effectiveness of SOF is that they attrite not only the enemy numbers, but more importantly, alter enemy attrition coefficients.

Looking at the Lanchester attrition model from this perspective suggests that the attrition coefficients are variables, not constants. Lanchester equations by their very nature discount the increasing lethality and concentration of force into smaller and smaller combat formations. Small variations in battlefield conditions have increasingly greater effect upon engaged units. As time progresses, the effects of surprise, morale, suppression, command and control, terrain, weather and supply, will exert their effects upon the ability of both sides to conduct attrition. These factors may enhance or diminish the attrition coefficients by affecting: the rate of fire, the accuracy of fire or the lethality of fire. The result is that it is increasingly difficult to model the ability of a given force to conduct attrition using constants for attrition coefficients. Revising the Lanchester square law to address the time varying

nature of attrition leads to the following relationship between the rates of attrition and enemy forces:

$$dx/dt = -\beta(t)y(t) \qquad dy/dt = -\alpha(t)x(t) \qquad [4.1]$$

In and of itself, this relationship offers a substantially different perspective on attrition. The real issue is to identify a more useful relationship between attrition coefficients and time. After all, there must be some linkage between time and the battlefield in order to find some useful relationship between conditions of combat and time.

If we think about the campaign combat model described heretofore, we can derive a useful relationship between attrition and time. Since each node represents a change in the conditions of a SOF mission, it is more useful to relate attrition to the nodes as opposed to simply thinking about attrition coefficients in terms of time. In truth, time in the absolute sense is not the critical independent variable, it is time in a relative sense that is important. The node that represents the forces gives us this relationship between time and battlefield "state". If we use relative superiority as a variable to capture the ability of each side to attrite the other, then we can establish several important relationships. First is that the relative superiority of a combatant, or potential combatant, is a penalty or an enhancement to the combat power (or potential) that varies at each node. It is in effect a function of the battlefield conditions that exist at a given point in the operation, not merely a particular point in time. Second, relative superiority will affect the combat power of the combatants differently. One way to apply RS quantitatively is as a multiplier for the SOF. We define relative superiority as a variable for the SOF force as:

RS(node) ≡ The relative superiority of the *SOF* at a given node [4.2]

In this way, the conventional force will suffer from the enhanced effectiveness of the SOF because of the linkage between equations.

Consider a nighttime engagement between American SOF and North Vietnamese regulars. The RS of the SOF is best when supported by the employment of night vision devices and superior training, but the NVA force suffers a severe penalty due to the lack of night vision equipment and training. The effects of RS increase the attrition capability of the SOF resulting in increased attrition of the NVA and therefore reduced attrition to the SOF. But it is clear that attrition rates are not merely affected by time but also by nodes when combat takes place. We see that the attrition coefficient α is a function of RS. If we let x(t) represent the SOF and y(t) represent the conventional force, we can revisit the Lanchester square law and write:

$$dx/dt = -\beta(t)y(t) \qquad dy/dt = -\alpha(RS)x(t) \qquad [4.3]$$

The attrition coefficient α is a now dependent upon the relative superiority of the SOF at a given node of the model and varies with respect to the advantages and disadvantages imposed on the forces at the nodes. For this example, we have used the Lanchester square law, but the analyst may wish to modify the linear or mixed laws to fit the situation. We wish to address, in practical terms, the real effect of attrition on the campaign model.

H. THE EFFECTS OF ATTRITION (WHY SOME MISSIONS FAIL)

Attrition is not the goal of asymmetric warfare, yet the effects of attrition, particularly when it occurs at inopportune times, is to drive the mission from its desired path. To illustrate this point, we turn to the simple campaign model and add transition probabilities to

the arcs as presented in figure 4.4. Since the progression of the model from node to node

Effects of Attrition on the Campaign Model

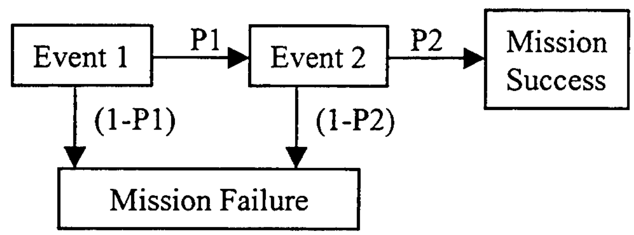

Figure 4.4

depends upon achieving certain goals within each node, we may assign a transition probability to the arcs connecting each node, recognizing that it is difficult to assign a value to these transition probabilities. If the probability of transitioning from node one to node two is p1: the effect of undesired attrition is to lower the value of p1. As suggested earlier in this chapter, these transition probabilities are often (but not always) influenced by attrition. This is a significant observation because it demonstrates in quantitative terms why a SOF mission fails when undesired attrition occur at a node or at a rate greater than the SOF can cope with. Furthermore, this insight tends to invalidate the use of a single Markov chain for the analysis of the campaign model. Because the transition probabilities from one state to another are generally depend on the outcome at all previous nodes, this violates the conditions necessary to treat the problem as a Markov chain, which require a series of independent probabilities not affected by previous events. (Ross, p 157) A prominent reason is that attrition at a previous event can affect the probability of transition from one state to another in subsequent events. The rate at which attrition occurs is affected not only by the number of firing entities, but in fact, by the state that the mission is in. In addition, we have failed to account for one of the most basic factors of combat: the effect of enemy bullets that miss, or suppressive fire.

I. SUPPRESSIVE FIRE EFFECTS

The question now arises on how to model suppressive fire and its effect upon the combat power of the opposing force. The U.S. Army defines suppressive fire in Field Manual 7-8 Tactics and goes into extensive effort to incorporate the concept of reducing (suppressing) enemy weapon effectiveness by the application of friendly fire. Simply put, not only does the design of the mission (modeled in the graph) determine the ability of the forces to affect the enemy's combat power, the man on the ground can diminish enemy attrition rates through suppressive fire. Yet there is a genuine paucity of reference to this tactic in the world of mathematical modeling. In his study of morale and other human factors in combat, Colonel Henderson notes: "The failure to consider the human element in war adequately and an overemphasis on weapon capabilities, numbers of troops, and other concrete factors are caused by the difficulty in quantifying the human element.". (Henderson, p3) For SOF, the exploitation of the human element is critical. For obvious reasons, a small force must leverage every advantage it has to forestall getting enmeshed in an attrition contest. This need is so great that SOF forces may be willing to accept a reduced attrition of enemy numbers, if it can trade that reduction for a greater survivability. This is a rational choice that allows the small SOF force to "stay in the ring" with a large conventional force and allow SOF to achieve to achieve its mission. This issue is how to incorporate suppressive fire into the model.

J. A SUPPRESSION MODEL

We propose to incorporate the effects of suppressive fire into the campaign model by further modifying the Lanchester square law. This extends the concept introduced by Prof

Wayne Hughes in which the Lanchester square law is modified to account for suppressive fire effects. Hughes reasoned that for two forces engaged in combat, x and y, the effects of suppression suffered by x are a direct result of the volume and accuracy of fire from y and vice versa. (Hughes, pg 4,5) The attrition coefficients in the Hughes model are time variant. To resolve the mismatch in units, coefficients of proportionality *g* and *h* are introduced and the resulting expressions for the effect of suppressive fire are:

$$d\alpha/dt = -g\beta(t)y \qquad\qquad d\beta/dt = -h\alpha(t)x \qquad\qquad [4.4]$$

The assumption is that attrition of the enemy is small compared with the rate that enemy fire is suppressed. Hughes' coefficients allow us to at least approach suppression in an abstract, if not realistic, sense. It also suggests that one field for future analysis might be the analysis of weapon effects to explore the trade offs between attriting a force as opposed to suppressing it.

K. ADDITIONAL COMBAT MODELING FACTORS

There are several untidy details that remain. These are not expressed in the model, but are points to consider in its application. The first point is time: when to terminate a battle due to "break points". Some combat models suggest that SOF might simply fight to the last operator. We know that this is seldom the case in conventional or in SOF missions. As a remedy, many attrition models incorporate break points as a percentage of remaining strength at which time a force will disengage and terminate the battle. Second, we suggest that the analysts recall that the small size of SOF will limit its ability to carry ammunition. A large conventional force can transfer ammunition from casualties to healthy soldiers and carry the fight. SOF starts with far fewer forces and often employs extremely heavy volumes of

firepower to attrite and suppress the enemy. The result is that SOF cannot remain engaged indefinitely and actual time that a SOF is engaged in combat must be accounted for. Thirdly, at some nodes the Lanchester linear or mixed law equations may describe the combat activity better than the square law.

L. REQUIREMENT FOR A CASE STUDY

At this point, we suggest that a detailed case study would be beneficial. A working example will allow use to not only apply the model, but to present a methodology for analysis of SOF combat missions. In the next chapter we will apply the model to the seizure of the Orne River bridges during the D-Day invasion and we will approach the subject from the view of an analyst called in prior to the mission. This case study will explore the various tools available to enable the analyst to deal with difficult modeling issues, as well as introduce the SOF to ways in which analysts can be incorporated into planning and improve mission effectiveness.

THIS PAGE INTENTIONALLY LEFT BLANK

V. PEGASUS BRIDGE: A CASE STUDY

A. PURPOSE

The seizure of the Orne River and Caen Canal bridges on June 6, 1944 by British glider troops is an excellent case study with which to apply the asymmetric campaign model. We hope not only to apply the model to the case study, but also to provide useful insight to the analyst interested in modeling SOF direct action missions. Our approach will be to establish why this particular engagement was selected, introduce a brief history of the engagement to include significant planning factors, break the battle into components, and finally to apply the model. Not only is this case a story of high human drama; it should give the analyst a useful point of departure for conducting both pre and post battle analytical work on SOF missions.

B. RATIONAL FOR STUDY

There are several factors that make this case study particularly compelling. First of all, the seizure of the bridges represents, as Professor John Arquilla of the Special Operations curriculum at the Naval Postgraduate School says: "A tough test": the success of the mission depended upon the seizure and defense of a bridge that was defended, fortified and wired for demolition. We have a difficult and highly important mission, contested by highly trained and motivated adversaries. This tends to rule out questions of legitimacy and luck. Furthermore, the principal consideration is the seizure of the bridges, which cannot be modeled using an attrition model like fire power scores or Lanchester equations. The engagement is also highly episodic: there are moments where the dynamics of the battlefield change dramatically. The various attrition models simply cannot represent these factors.

The scenario contains many of the elements of "modern" SOF direct action missions: a strategic objective, long-range insertion, specialized training and equipment, exceptional intelligence gathering and a compelling story. One additional factor that makes this case somewhat unique is that the British forces involved in the attack were put into regular combat as a conventional infantry unit almost immediately after the seizure of the bridges, and often against the same German formation. This allows us to do some interesting analysis of attrition coefficients during the SOF and conventional phases of the operation. We now address the historic circumstances of the operation.

C. HISTORICAL BACKGROUND

Pegasus bridge was the code name given to the two bridges over the Orne River and Caen Canal during WWII: vitally important access routes into and out of the Normandy D-Day invasion beaches in France. Control of the bridges was critical to the Allies, both as an exit off of the invasion beaches, as well as a defense of the eastern flank of the entire Allied invasion force from German panzers. The bridges had to be seized and held until the British 3rd Division arrived from Sword Beach to consolidate the defense of the bridges. This required the use of airborne troops to seize the bridges and the approaches to them; a task given to the British 6th Airborne Division. Figure 5.1 is a map of the Benouville area and shows not only the main landings by the British 6th Airborne Division, but the principal threat to the Allied invasion force: the German 21st Panzer Division. (Ambrose, p66) The Germans understood the significance of the bridges and prepared them for rapid demolition at the outset of an Allied invasion. The British problem was how to seize the bridges before they could be demolished and to hold them in the face of vigorous German counter-attacks. Major General Gale, commander of the 6th Airborne Division, chose to employ a SOF to

The Allied Disposition on the Eastern Flank of the Normandy Invasion Beaches

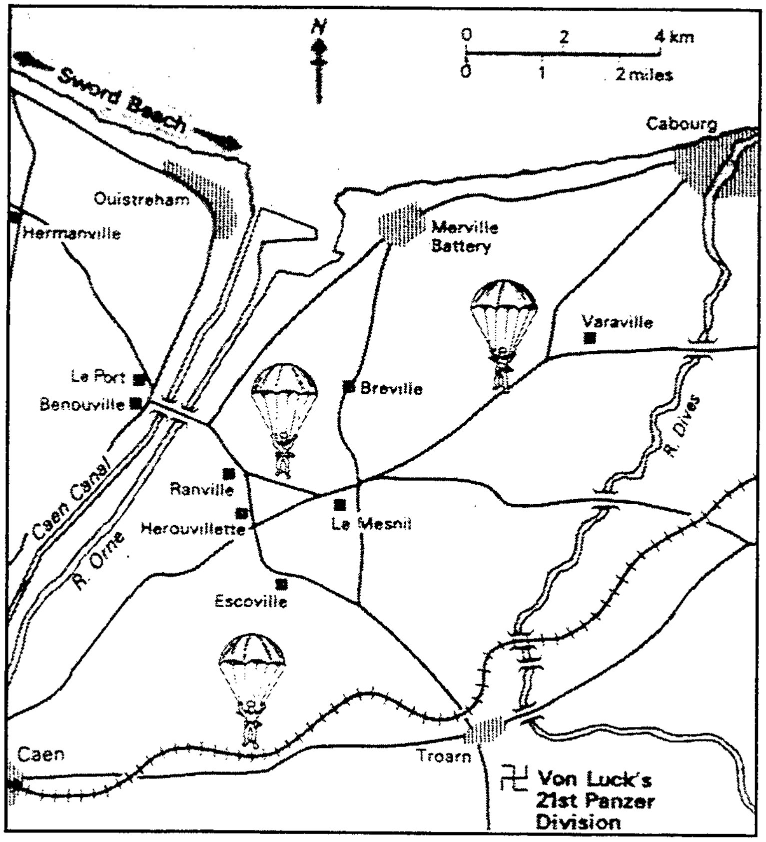

Figure 5.1 (Ambrose, p66)

conduct a *coup de main* seizure of the bridges, and then employ the rest of the 6th Airborne Division to attack other individual targets in an effort to forestall the 21st Panzer Division. (Nalty, pg 97) Gale's plan was to fly a reinforced company of glider troops to France, land the force in areas adjacent to the bridges, assault the garrison, clear the bridges of demolitions and then defend the bridges for approximately 12 hours until the 3rd Division arrived.

The task of assaulting the bridges was daunting enough, but doing so before the German garrison could destroy the bridges with prepared demolitions was a risky

proposition. But the high payoff from a successful attack made the risk worthwhile. General Gale, explained:

> There is always or nearly always a slip between the cup and the lip: orders are vague: there is uncertainty: has the moment arrived or should one wait? Who is the individual actually responsible both for working the switch and ordering the bridges to be blown? These questions are age-old and on the doubts that might exist in some German mind or minds at the critical moment I based the plan. But a moment or two was all I knew we would get. The assault on the bridges had to come like a bolt from the blue." (Ambrose, p64)

The Commander of the independent assault company, D company, Major John Howard, was given extraordinary discretion in the selection and training of his force beginning thirteen months prior to the assault. (Ambrose, p47) Howard's force totaled 150 men in six platoons and a force of 31 sappers. The German garrison at the bridge consisted of a badly under-strength infantry company, perhaps 50 infantry on alert, but the garrison clearly had the advantage: if they had sufficient time to detonate the charges.

Howard's key to success lay in getting his men onto the target quickly and overwhelming the garrison: particularly the pillbox that held the detonators. Tactical success depended upon surprise and the accurate glider insertion of Howard's force. To achieve this, D Company had to land on a 600 meter long "L shaped" field, in between the bridges, and atop the German defenders, preferably without raising the alarm. To achieve this difficult task, the glider pilots were subjected to an exhaustive training program that culminated with them flying 43 training flights in their six specially constructed Horsa gliders, either with blacked out goggles or at night, regardless of weather conditions. (Ambrose, pg 61-62) This intensive effort demonstrated that D Company, could be landed on target with high probability: the question was could they seize the bridge in time?

To validate the concept that D Company could seize the bridges intact, General Gale scheduled a major exercise to simulate the attack. (Ambrose, p 50) This exercise showed that the mission was feasible, but critical questions about the German forces remained. To answer these questions, British intelligence compiled daily reports that included photographs and reports on every feature of the Area of Operations (AO) and German troop dispositions. (Ambrose, p 73-74) In addition, D Company trained on mock-ups of the bridges and defenses that were accurate down to the smallest details. (Ambrose, p 74-75) Howard calculated that he could seize the bridges if he got three of his six gliders next to the bridges. To complete his mission, Howard had to reckon with inevitable German counter attacks. (Ambrose, p 67) The attacks were expected to be disorganized, in no greater than company strength, and were not expected for two hours. Then, intelligence predicted, determined counter-attacks from the German 21^{st} Panzer division would follow. (Ambrose, p67-73)

D. THE ATTACK

The glider attack on the Orne and Caen Canal bridges was extraordinarily successful. Between 0016 and 0021 hours, five of the six gliders landed at the bridges; # 1 glider actually smashed through the barbed wire of the German perimeter defenses: right on target. (Ambrose, pg88-100) Figure 5.2 shows the actual landing positions of Howard's force. The # 4 glider landed safely, but on the wrong target, the bridge over the river Dives, and due to the distance, its passengers were unable to rejoin D-Company for the remainder of the mission. (Ambrose, p 28) The loss of the glider was not critical; the rest of D Company landed sufficiently close to their targets and were able to quickly mount the assault. By 0021 hours, the pillbox (and the critical detonator) was captured: the garrison was defeated and sappers were completing the task of clearing the bridge of explosives. Thirty minutes later,

the entire British 6th Airborne division started landing at 0050 to help protect the vulnerable approaches to the bridges. (Ambrose, p109) By 0115 Howard established his defense of the bridges. (Ambrose, p113)

The Operational Plan

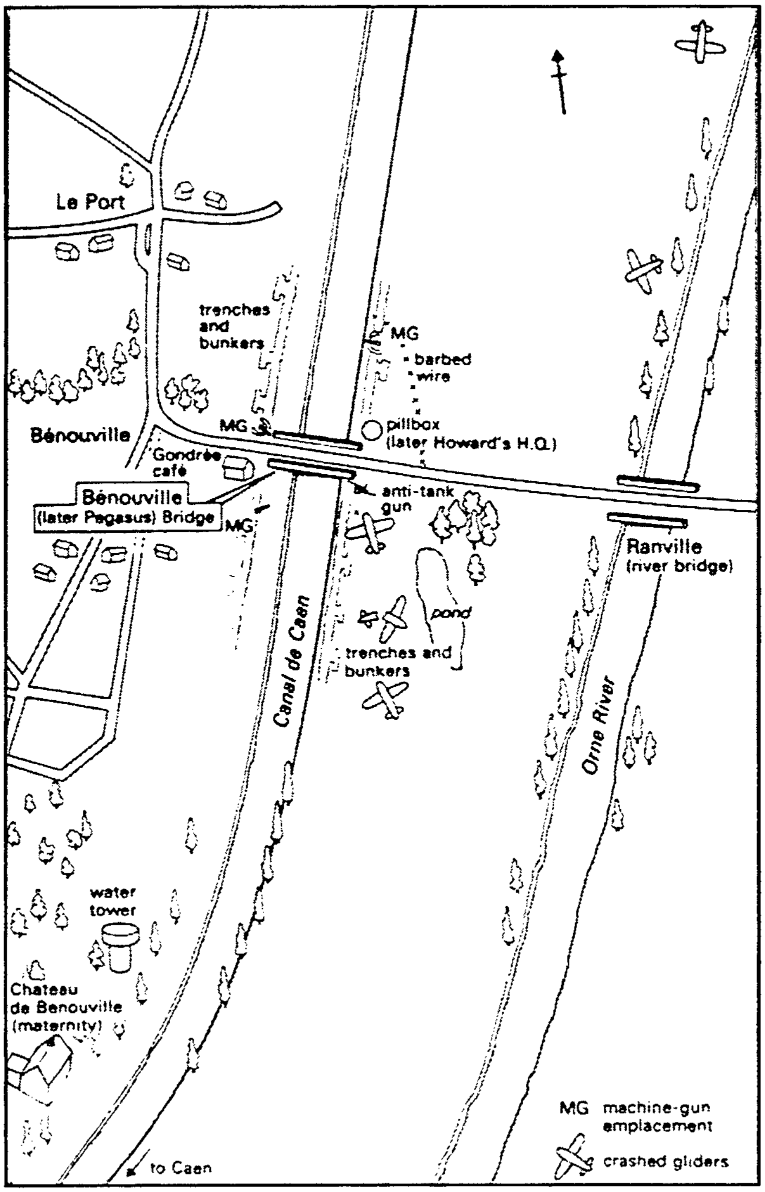

Figure 5.2

Howard did not have to wait long for the Germans to launch their counter-attack. The Germans possessed large reserves in the area surrounding Benouville. Per doctrine, they launched an immediate counter attack. The attack began at 0130 and unexpectedly included several armored formations. Howard possessed comparatively weak defenses against armor, but fortunately for the British, the first shot of the engagement killed the commander of the 1st Panzer engineering company of the 716th infantry, the lead element of the attack. In the ensuing confusion, the senior surviving German officer reported "...the British have 6-pounder anti tank guns [and] the Germans decided to wait until dawn to clarify the situation". (Ambrose, pg118-119). The German decision to delay their attack sealed their fate. When dawn came, Allied aircraft supporting the invasion were able to disrupt German attempts to move large armored formations to the bridges. Lord Lovat's commandos, the advance element of 3rd Division, arrived at 1300, playing their bagpipes in announcement of their arrival and relief of D Company. (Ambrose, p146) In total, D Company suffered fourteen casualties including two dead during the operation (Ambrose, p126), only one man died during the landing: he drowned. (Ambrose, p 93) This was an exceptionally successful outcome by any standard.

E. A CAUTIONARY NOTE

What occurred after the seizure of the bridges is equally instructive to the analyst because it gives use a basis for comparing the effectiveness of D Company when employed asymmetrically in a SOF role with its effectiveness when employed against the same enemy, but as a conventional force. Immediately after the D-Day landings, the Allies found themselves fighting an attrition campaign against the Germans, and short of infantry, D

Company was employed to 'bolster the line': "D Company, in short, became an ordinary infantry company." (Ambrose, p150) In this role, D company performed as well as the best, but did not achieve the incredible, nearly casualty free success that it enjoyed only a week earlier. In fact, by D Day plus four, D Company had less than fifty men out of its original compliment of 150 soldiers. (Ambrose, p156) "On June 6 it [D Company] had been at the cutting edge of tactical innovation and technological possibilities. On June 7 it was fighting with the same tactics ordinary infantry companies used thirty years earlier, at Mons and throughout World War I". (Ambrose, p156) Major Howard further describes repeated instances of shell shocked troops, self inflicted wounds and other morale problems (Ambrose, p156-157) This clearly demonstrates several key points about modeling attrition coefficients. Simply put, SOF forces cannot be modeled by inflating attrition coefficients or firepower scores.

F. MODELING PEGASUS BRIDGE

The analysis of the Pegasus Bridge operation starts with the construction of the event graph model. Figure 5.3 shows the campaign model with the critical nodes established. The

The Campaign Model of Pegasus Bridge

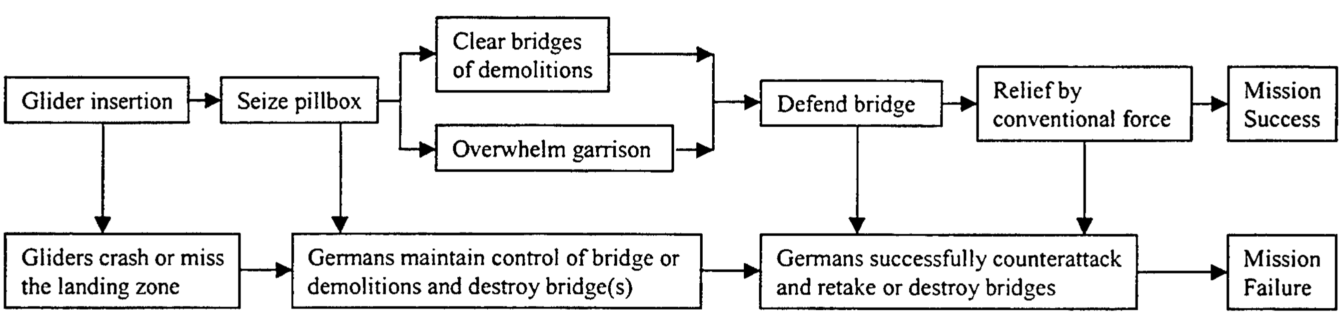

Figure 5.3

critical nodes are obtained directly from the operation plan established by General Gale and Major Howard. The analyst then lays out a rough time line corresponding to the event graph and establishes, in general terms, a graph of relative superiority. This brings the interesting features to light. Several factors immediately stand out: first is that the mission passes through three distinct phases where D Company is both attacker and defender of the bridges; second is that the amount of time in the mission where D company was expected to use its special capabilities was comparatively short, only minutes out of a 12 hour mission; and finally, the time it would take the Germans to decide to destroy the bridges and then carry out that decision was simply a professional guess. Continuing the analysis, the analyst next examines the decisive node first as it affects every aspect of the operation. In many cases, this will require the analyst to start somewhere in the middle of the operation.

Analysis of the most critical node in the operation: the seizure of the pillbox and the neutralization of the explosive detonators was at best, a matter of judgment. The only thing the analyst can do to resolve this action is to consult the commander and the intelligence branch to make a "best guess" approximation. General Gale certainly had a strong opinion of the risks and benefits involved in a *coup de main* seizure of the bridge. The assessment of the British officers involved in the planning and execution of the mission was that the SOF would have sufficient relative superiority to seize both bridges intact, provided they were inserted close to the target and if the SOF had the element of surprise. Both of these factors were beyond the expertise of the analyst. However, the critical measure of effectiveness that an analyst could have employed was time. Given an estimate of time, the analyst can resolve key factors in the insertion node leading to the seizure of the pillbox. Those key issues are the expected number of gliders to arrive, the expected distance from the gliders to the

pillbox, and the time required to neutralize the pillbox. Once these issues are resolved, the analyst can recommend a series of exercises that could be used to gain a level of confidence about the probability of seizing the pillbox.

Working backwards from the glider insertion, the analyst can use various statistical analysis and stochastic techniques to monitor the training and effectiveness of the glider insertion. Analysts might also use optimization techniques such as game theory to address the order and locations of landings around the target in an effort to deliver the SOF to the target with greater speed and higher probability of successful landings. Analysis of this sort, conducted as the preparation for the mission progressed, might also reveal design deficiencies in the gliders, transports or the landing plan. Yet the greatest benefit of analysis might be realized in looking at the operation *after the seizure of the bridges.*

A careful examination of mission time line suggests that the greatest vulnerability to the SOF occurs after the seizure of the bridges (figure 5.4). This occurs for two very

British SOF Relative Superiority vs Time

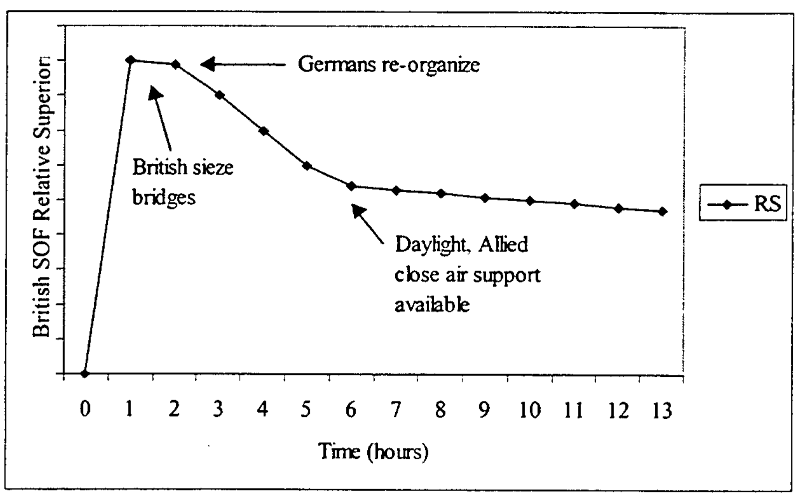

Figure 5.4

important reasons: first, once the SOF seizes the bridges and establishes a defense, it is

essentially a specially trained infantry company, and second, the greatest uncertainty about the enemy concerns the actions of the German 21st Panzer Division as opposed to the German garrison of the Orne and Caen river bridges. Commander Bob Harger noted in 1989 when he was the executive officer of SEAL Team EIGHT: "At those times when SEAL special skill areas are not being employed: ***beware***[.] At those times you are just another combat force without … the heavier firepower to deal with armor and or other unexpected [emergencies]." (Harger) Applying this logic to the Pegasus Bridge, there is clearly a very lengthy period in which Howard's company was expected to defend the bridges against potentially overwhelming German forces. This is shown in figure 5.4, which plots relative superiority versus time. Even without the benefit of hindsight, it is clear that Howard faces an eleven to twelve hour window of vulnerability, during which his force is subject to a division sized assault by enemy armored and mechanized forces. The lack of large caliber anti-tank weapons puts Howard's men at a serious disadvantage, even with the aid of the British 6th Airborne Division. The area of greatest vulnerability is clearly between 0200 and daylight, because at dawn, Allied airpower can be employed effectively against the Germans. Moreover, the advantages that D Company enjoyed during the initial assault are clearly degrading over time as the Germans alert their forces, identify the threat and decide on a course of attack.

Given this problem, the analyst might assist the SOF by suggesting several courses of action. The first would be to reinforce Howard's force with a better anti-tank defense, even if it came at the expense of some of the 6th Airborne Division assault forces. The technology to deliver artillery and light anti-tank guns existed and was employed by allied forces, but these weapons were not incorporated into the Pegasus Bridge operation. The methodology

here would be to evaluate the effectiveness of differing forces structures against the German threat, taking into account losses due to "miss-drops" or losses upon landing. The second method of analysis might include a game theory approach to evaluating German vs. British options. Finally, the deployment of the British 6^{th} Airborne Division might be treated as a network flow problem in which the British goal would be to disrupt the road network over which the German forces must move in order to regain the bridges and move to the invasion beaches.

We have attempted to not only apply the campaign model but to show how analyst might bring their skills to bear on a problem. Evidently, a mathematical combat model or computer simulation of the assault has no value. We emphasize the need for the analyst and the SOF to cooperate and to take advantage of the expertise of one another. In too many instances, the SOF is either unable to articulate its needs or discounts the usefulness of analysts in general. On the other hand, many analysts are guilty of self-delusion, believing that they can produce a deterministic or stochastic model that will realistically represent all aspects of combat and predict the future. We have shown that a simulation based approach has little or no value, but that an orderly campaign approach to describing mission attainment can be of great value to SOF and to the commanders responsible for ordering SOF operations.

VI. CONCLUSION

A. OVERVIEW

This project represents an effort to take a hard and critical look at asymmetric warfare and how to apply operations research methods of analysis. We hope that analysts will embrace the campaign approach as a promising methodology for SOF operations. There are gaps and unrefined areas that require further development. Nonetheless, we feel that what has been presented here is a viable, valuable way with which to approach SOF mission analysis.

This thesis has examined SOF operations and carefully considered several themes to highlight. First, future analysis of SOF operations should treat the operation as a campaign composed of distinct events for the purpose of analysis. Second, it is vital to differentiate between combat potential and combat power. A SOF intends to use its combat potential to the fullest while preventing conventional forces from transforming greater combat potential into useful combat power. Third, McRaven's concept of relative superiority should be extended and incorporated as a variable that captures the effect of translating combat potential into combat power. Fourth, the number of fighting elements on the two sides are not the only variables in a combat model: the attrition coefficients of individual elements must also be treated as variables. Finally, we point to mathematics of suppression in which victory goes to the side with more effective suppression of enemy fire and maneuver.

Our intent has not been to throw stones at conventional analysis, but to improve the quality of analysis and support for asymmetric warfare. Nor do we intend to dismiss any analytic tool out of hand. As we increasingly focus on enemy vulnerabilities and less upon enemy numbers, it is obvious that simple attrition will become less pertinent in future military operations.

B. RECOMMENDATIONS FOR FUTURE ANALYSIS

There are two areas of concentration that broadly define the "road ahead". The first is a historical study of past special operations and other forms of asymmetric warfare using the campaign model approach. Of these historical examples, we suggest revisiting not only SOF engagements, but also examining conventional forces that employed asymmetric strategies to achieve victory. The German Army's Blitzkrieg into France in 1940 is perhaps the greatest example of an asymmetric strategy applied by a "conventional army" against a conventional attrition, or symmetric strategy.

The second area of concentration is an investigation of the analytic tools and methodology to aide current and future SOF. Of these, there are several areas that would benefit substantially from additional analysis: the effect of suppressive fire on enemy return fire and maneuver, the collection of data on the effects of attrition and on the transition times from node to node, and finally, a systematic assessment of relative superiority as a variable. We hope that a serious investigation into these themes may be useful to the end beneficiary of analysis: the SOF.

LIST OF REFERENCES

Ambrose, S. E., *Pegasus Bridge*, Touchstone, 1985.

Devore, J. L., *Probability and Statistics*, Duxbury. 2000.

Dewar, J. A., Gillogly, J., J., Juncosa, M. L. Military Operations Research, V2 N2 *Non-Monotonicity, Chaos and Combat Models*. 1996.

Dupuy, T. N., *Numbers, Predictions and War,* The Bobbs-Merrill Company. 1979.

Harger, R., *Mission Planning Class for SEAL Team EIGHT.* 1989.

Operations Research Department, *Aggregated Combat Modeling*, Operations Research Department, Naval Postgraduate School, Monterey, California, September 1999.

Henderson W. D. *Cohesion: The Human Element in Combat.* National Defense University Press, 1985.

Hughes W. P. *Two Effects of Firepower: Attrition and Suppression,* Military Operations Research Journal, Volume One, Number Three. 1995.

Leonhard, R. R., *The Art of Maneuver*, Presidio Press. 1991.

McRaven, W. H. *Spec Ops*, Presidio Press. 1995.

Nalty, B. C., *D-Day, Operation Overlord.* Smithmark Publishers, 1993.

Ross, S. M. *Introduction to Probability Models (sixth edition),* Academic Press, 1997.

Ryan, C. *The Longest Day*, Touchstone. 1953.

USSOCOM Pub 1 *Special Operations in Peace and War*. 1996.

U.S. Army Field Manual FM 7-8 *Tactics*.

U.S. Army Field Manual FM 101-5, Chapter 5 *Military Decision Making.*

Vandenbroucke, L. S., *Perilous Operations, Special Operations as an Instrument of U.S. Foreign Policy*, Oxford University Press, 1993.

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1.	Defense Technical Information Center 8725 John J. Kingman Rd. Ste 0944 Fort Belvoir, VA 22060-6218	2
2.	Dudley Knox Library Naval Postgraduate School 411 Dyer Rd. Monterey, CA 93943	2
3.	Professor Wayne H. Hughes Operations Research Department (Code OR/Hl) Naval Postgraduate School Monterey, CA 93943-5000	1
4.	Professor Gordon H. McCormick Chairman, Special Operations Academic Group (Code CC/Mc) Naval Postgraduate School Monterey, CA 93943-5000	1
5.	United States Special Operations Command SOOP-JE 7701 Tampa Point Blvd McDill AFB, FL 33621-5323	2
6.	Jennifer Duncan Special Operations Academic Group Code (CC/Jd) Naval Postgraduate School Monterey, CA 93943-5000	3
7.	Library Naval War College Newport, RI 02840	1
8.	Library Army War College Carlisle Barracks, PA 17013	1

9. Department of Military Strategy 1
National War College (NWMS)
Ft. Leslie J. McNair
Washington, DC 20319-6111

10. US Army Command and General Staff College 1
ATTN: Library
Ft. Leavenworth, KS 66027-6900

11. Library 1
Air War College
Maxwell AFB, AL 36112-6428

12. US Naval Academy 1
ATTN: Library
Annapolis, MD 21412

13. US Military Academy 1
ATTN: Library
West Point, NY 10996

14. Maraquat Memorial Library 1
US Army John F. Kennedy Special Warfare Center
Rm. C287, Bldg 3915
Ft. Bragg, NC 28307-5000

15. US Special Operations Command 1
ATTN: Command Historian
McDill AFB, FL 33608-6001

16. US Air Force Special Operations School 1
EDO, Alison Bldg, 357 Tully St.
Hurlburt Fld FL 32544-5800